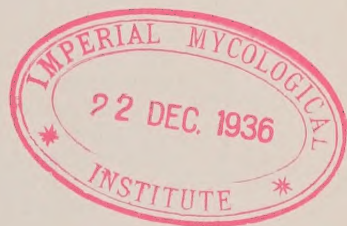

New York State Agricultural Experiment Station
Geneva, N. Y.

WILD BRAMBLE ERADICATION

L. M. COOLEY



PUBLISHED BY THE STATION
UNDER AUTHORITY OF CORNELL UNIVERSITY

ABSTRACT

FROM 1932 to 1935, various means of eradicating wild *Rubus*, chiefly red raspberries, were studied comparatively in western New York. Customary methods of exterminating brambles, such as mowing, burning, grubbing, clean cultivation, and livestock grazing, were tested extensively. All proved effective when managed correctly. The advantages, limitations, and proper use of each of these means of eradication are discussed briefly. Clean cultivation, where it can be employed, is still probably the most preferred method.

In many situations where none of the customary methods is expedient, recourse may be had to chemical treatments. In experimentation along this line, the effective bramble eradicanants proved to be ammonium sulfocyanate, both crude-liquor and crude-crystalline; sodium chlorate and the proprietary chlorate mixtures, Atlacide and Vegecide; and sodium arsenite. The nature, source, and risks connected with the use of each of these materials are discussed. Recommendations are made, based on results obtained in plat experiments and field trials, as to rates, methods, and season of application.

Other chemicals tried but found to have comparatively slight or no value in the destruction of brambles included sodium chloride, kerosene, sulfuric acid, lime-sulfur, copper sulfate, ammonium sulfate, calcium cyanamide, sodium nitrate, and sodium carbonate.

Of the several types of wild brambles treated, blackberries proved most resistant to the toxic chemicals. The purple or hybrid raspberry, a relatively rare species, was also quite resistant. Red raspberries, black raspberries, and dewberries all succumbed readily. In a given species, resistance to herbicide rose markedly with increased vigor of bramble growth.

WILD BRAMBLE ERADICATION

L. M. COOLEY

Associate in Research (Plant Pathology)

INTRODUCTION

Farmers generally regard wild brambles as obnoxious and pernicious weeds. Briar patches are unsightly, are mean for man and beast to work around, and are wasteful occupants of the land. But besides being an aggravating general nuisance, wild brambles are also a potential menace to cultivated raspberries and blackberries from the standpoint of disease and insect pests. Serious diseases in cultivated raspberries and blackberries that may be disseminated from wild hosts include the fungous maladies, anthracnose and orange-rust, and the virus troubles, mosaics, leaf curl, and streaks. Wild brambles also harbor such insect pests as the raspberry fruit-worm, the saw-fly, the tree-cricket, and the cane-borer.

A major development of recent field investigations on the control of raspberry virus diseases in western New York was the revelation of the practical importance of wild red raspberries as sources of mosaic infection. In instances of certain experimental black raspberry plantings where wild red raspberries in the vicinity constituted the sole source of mosaic infection, the incidence of mosaics increased steadily in spite of a systematic inspection and roguing program. After the wild red raspberries were eradicated, mosaic occurrence in these plantings declined rapidly. These results have been presented in detail in Bulletin No. 665 of this Station.

As is only natural, all types of wild brambles, but especially the red raspberry, abound in the sections of New York State that are adapted to commercial production of bramble fruits. Their extermination is not always of easy accomplishment; consequently, studies of the efficiency of various means that might be employed were undertaken and this work came to be an important phase of the raspberry mosaic control project.

The observations and experiments reported herein were made primarily on the wild red raspberry, as it is the species not only most abundant but most menacing to commercial raspberry production in western New York. Mixed stands containing other species of brambles,

however, were frequently encountered. These afforded opportunities for observing also the reactions of wild black and purple raspberries, blackberries, and dewberries to eradivative treatments.

COMMON METHODS

The experiences of farmers with various methods of subduing brambles were gathered in conversations. Trials of all the suggested treatments were made by the writer and, on a more extensive scale, by cooperating berry growers in Erie and Chautauqua counties. The observations and results accruing from these experiences are summarized herewith.

CLEAN CULTIVATION

It is significant that wild brambles seldom occur to any extent on areas of land that are regularly cropped. There is abundant evidence in ordinary farm practices that wild brambles succumb to the clean cultivation method of weed eradication, especially when applied in the form of a "hoed" crop. Because it requires no extraordinary equipment or preparation and because the same efforts that exterminate the brambles will simultaneously produce a crop of economic value, this age-old method is still advisable to use wherever practicable.

GRUBBING

For the black raspberry, digging out the crowns with a mattock is a rapid and inexpensive, yet effective, method of disposition. Individuals of this species propagate naturally only by seeds or the rooting of cane tips, and cannot renew growth to any extent by suckering from the roots.

Against other species of wild *Rubus*, all of which have extensive systems of underground stolons or rootstocks, this means is laborious and avails but little unless followed up with clean cultivation.

MOWING

Of the various methods that might be used to get rid of wild brambles, unsupplemented mowing is the one most frequently tried and ordinarily the least effective. All *Rubus* species have perennial crowns and roots and cutting off the canes above-ground handicaps them only temporarily. Growth of new shoots is prompt and rapid. Very frequently with red raspberries and blackberries, a single mowing results only in an amazing increase in the number of new shoots and an en-

hanced vigor of growth. However, if practiced several times each season and if followed for 2 years or longer, mowing will eventually eliminate the most stubborn of wild bramble clumps thru the combined effects of starvation and winter injury to the abnormally succulent late autumn growth.

BURNING

Burning over a clump of wild brambles, either as it stands or after mowing, does not usually effect its extermination; in fact, this practice often favors the brambles thru eliminating the competitive growth of small trees and shrubs. Burning has proved effective, however, in instances where large quantities of dry brush have been piled on bramble patches prior to firing. The burning of the extra material produces a higher heat intensity and maintains it for a period of time sufficient to penetrate the soil and kill the crowns and rootstocks.

This method is now being employed extensively by berry growers in western New York with worthwhile results. Each autumn and spring great quantities of prunings have to be removed from the raspberry fields and disposed of. With but little additional effort, these prunings are piled and burned on nearby clumps of wild brambles instead of in random locations as formerly. As a consequence, the number and extent of growth of wild red raspberries around the borders of the cultivated berry plantings are being curtailed appreciably each year.

GRAZING OF LIVESTOCK

Wild brambles are never found thriving in good pastures. They grow scatteringly in a subdued state in pastures of medium grade, while in scantily grazed woods pastures they are often found flourishing unhampered.

Cattle and sheep will browse on the growing tips of the young canes of all the wild bramble species, but especially on those of the less briary red raspberry. Older foliage on the woody and prickly mature canes will not be eaten by livestock except to avoid starvation.

Close pasturing, if begun in late April or early May, by the trampling and the constant feeding on new shoots, will subdue the growth of wild red raspberries gradually to a point where they are of no consequence as a virus source, and eventually will kill them out completely. Grazing is a method that can quite frequently be resorted to without involving much labor or expense. Changing a fence line, to allow stock to range over a former fence row or over wasteland adjacent to a pasture, is sometimes a simple way to get rid of the brambles.

On the other hand, extermination of brambles by grazing is a slow process at best and requires the exercise of judgment. If grazing is sufficiently early and restricted to accomplish a rapid killing of the brambles in a given area, it will be detrimental to any desirable forage plants growing thereon and will not supply adequate nourishment to the stock.

CHEMICAL TREATMENTS

In many situations none of the foregoing common means of dealing with wild brambles is practicable or economically advisable. The present-day natural habitats of wild raspberries and blackberries are along the borders of woodlots, on wastelands, in fence rows, and on steep or stony land. Good farming practices would seem to have already suppressed the brambles in locations where it could be done readily with the usual methods. The development of some extraordinary measure appeared necessary. The most promising seemed to be the use of toxic chemicals or "herbicides". Experiments were conducted to determine not only what materials would be effective, but also at what rates, by what methods, and at what seasons they should be applied.¹

The conditions of these experiments and the data obtained are detailed in Tables 1 to 4, inclusive, pages 28 to 32. Proper consideration in all instances should be given to plat conditions. Detailed descriptions of these are not possible either in the text or tables of this bulletin. In their stead, each plat has been given a vigor-index number on an imaginary scale of 1 to 10. (See footnote to Table 1 and Figs. 1, 2, and 3.)

GENERAL TESTS

The following materials were given general trials: Ammonium sulfate, ammonium sulfocyanate (30 to 35 per cent crude liquor), ammonium sulfocyanate (crude crystalline), calcium cyanamide, copper sulfate, kerosene, lime-sulfur, sodium arsenite, sodium carbonate, sodium chlorate, Atlacide, Vegecide, sodium chloride, sodium nitrate, and sulfuric acid.

These general trials were made at four different times, *viz.*, in the autumn of 1932; in the spring and autumn of 1933; and in the spring of 1934. Except those in the spring of 1933, all treatments were made

¹The author wishes to acknowledge his indebtedness to Mr. H. A. Runnels of the Ohio Agricultural Experiment Station who, at the outset of this work, supplied him generously with information about herbicides on wild blackberries from unpublished data and experience.



FIG. 1.—THIN STAND AND WEAK TO MODERATE GROWTH OF WILD RED RASPBERRIES UNDER HEAVY SHADE, TYPIFYING A VIGOR-INDEX OF 4.



FIG. 2.—MODERATE STAND AND UNIFORMLY VIGOROUS GROWTH OF WILD RED RASPBERRIES, REPRESENTING A VIGOR-INDEX OF 6.



FIG. 3.—DENSE STAND AND TALL GROWTH OF MIXED WILD RED RASPBERRIES AND BLACKBERRIES, TYPICAL OF VIGOR-INDEX OF 9.

on measured plats of 100 square feet. Wherever possible, applications were made in the form of a fine mist spray on the bramble foliage. In the two exceptions, calcium cyanamide was dusted on foliage and sodium chloride was distributed dry on the soil surface (Table 1).

The effective bramble eradicants proved to be ammonium sulfocyanate, both the crude liquor and crude crystalline forms; sodium chlorate and the proprietary chlorate mixtures, Atlacide and Vegecide; and sodium arsenite. The effectiveness of crude crystalline ammonium sulfocyanate and of the chlorates was proved further in the experiments on rate, method, and time of applications (Tables 2, 3, and 4).

Sodium chloride proved relatively ineffectual. Rock or "ice cream" salt was used as this is the cheapest form as well as the one most toxic to plants. Little effect was noted from an autumn application of 10 pounds per 100 square feet. At an excessive rate of 100 pounds applied in the spring, the wild red raspberries were not entirely killed but by the following autumn their stand and growth had been reduced to 5 per cent of the original condition. Some recovery followed later.

Kerosene (2 gallons per plat) and sulfuric acid (2 gallons of 25 per cent concentration per plat) both caused prompt and severe burning

and death of the above-ground parts, but their ultimate effectiveness in eradication was not worth while.

Lime-sulfur solution (33° Baumé), when applied undiluted at the rate of 2 gallons per plat, caused severe burning and complete defoliation shortly after application, but the following spring bramble stand and growth were not greatly reduced over the original condition.

Copper sulfate at the rate of 4 pounds dissolved in 2 gallons of water and sprayed on the foliage of a plat 100 feet square had little eradivative effect.

Ammonium sulfate, calcium cyanamide, and nitrate of soda, all well known as nitrogenous fertilizers, when applied extra heavily as herbicides produced but little immediate toxic effect, comparatively, and even this was more than offset subsequently by the fertilizing effect on the soil.

Sodium carbonate proved entirely worthless.

EFFECTIVE MATERIALS

Chemical means of eradication in comparison with the usual methods save time and energy in bramble extermination. Also, they may be employed in situations where other methods are impractical. Against these advantages should be weighed the cost of materials, use of spray equipment, and certain risks. A consideration of these factors in relation to the conditions under which bramble eradication is to be attempted will determine when chemical treatment should be resorted to and which one of the several effective materials should be selected for the work.

AMMONIUM SULFOCYANATE PRODUCTS

As herbicides, crude ammonium sulfocyanate materials have proved more effective than the purified grades;² consequently, it was these forms that were tried in the wild bramble eradication work. The crude liquor tested was dark reddish brown in color and had a sulfocyanate content of 30 to 35 per cent, or the equivalent of 3 to 3½ pounds of crystals in each gallon. This material has a repellent odor. It is non-inflammable. The cyanide present in it is not liberated actively enough to constitute a poison hazard unless taken internally in considerable quantity. Crude crystalline ammonium sulfocyanate is derived from this "mother" liquor. Chemically, it differs from the liquor chiefly in the lack of oil impurities.

²Sauchelli. V. Summary of progress reports on field tests of ammonium sulfocyanate weed killer. Undated mimeograph issued by Koppers Products Company, Pittsburgh, Pa.

Experiments.—Crude crystalline ammonium sulfocyanate was tested more extensively against wild brambles than the crude liquor form. In the first experiment with this material, September 26, 1932, 4 pounds of crystals were dissolved in 2 gallons of water and sprayed as a fine mist on the foliage of a 100-square-foot plat having a vigor-index of 6. Approximately 95 per cent eradication had been achieved by June, 1933;³ however, appreciable recovery of growth from the surviving 5 per cent of the brambles ensued in the remainder of that growing season (Table 1). Nearly identical results were obtained with the same treatment under similar conditions in an experiment on rates of application made on October 27, 1932. Rates of 4, 2, and 1 pounds per plat in this series gave 95, 60, and 25 per cent eradication, respectively (Table 2).

In experiments on different methods of application made in October, 1933, crude crystalline ammonium sulfocyanate gave 70, 82, 78, 63, and 50 per cent kill of brambles when used at the rate of 2 pounds per plat and applied on the foliage, respectively, as a fine mist spray under low pressure, as a fine mist spray under high pressure, as a coarse spray under high pressure, by sprinkling, and by dry sifting. Applying this material on the soil surface by three different methods in this same series not only did not eradicate the wild red raspberries, but in every instance actually stimulated their growth over that of the untreated adjacent brambles (Table 3).

In experiments made in 1934 to determine the best time of treatment, this material, applied at the rate of 2 pounds per plat on foliage with a fine mist spray under low pressure, gave 98, 98, 100, 100, and 95 per cent eradication resulting from applications on May 24, June 11, July 18, August 17, and September 20, respectively. A winter treatment (December 6) in the same series gave only a 20 per cent reduction in stand as of June, 1935, and this was more than recovered during the growing season following (Table 4).

The crude liquor material was tested as a bramble eradicator in two field demonstrations on May 29 and 30, 1933. In relatively heavy applications estimated at 2 and 1½ gallons, undiluted, per 100 square feet of land area (equivalent, respectively, to at least 6 and 4½ pounds of crystals) eradications of 100 and 98 per cent, respectively, were achieved (Table 1).

Discussion.—The most obvious feature of the experiments with ammonium sulfocyanate materials as bramble eradicants was their variability in effectiveness. Season and method of application seemed to affect the results obtained with these products. When applied in mid-summer of a drouth year (1934), 2 pounds of crystals per 100 square

³In the text discussion of treatments with effective materials, results are given in terms of percentage eradication. In the tables, results are given as comparisons with original conditions. For example, 95 per cent eradication equals 5 per cent original growth condition.

feet were completely eradicated, whereas dosages of twice this quantity had been less effective in spring and autumn treatments of 1932 and 1933. In general, summer applications of ammonium sulfocyanate were most effective while spring treatments proved more eradicated than autumn. To obtain worthwhile results with these materials, it seems almost imperative that they be applied as a spray on foliage. Autumn and winter applications to soil surfaces invariably were not eradicated but instead actually stimulated bramble growth. But there can be no doubt that when applied in proper rate and manner and in a favorable season, ammonium sulfocyanate is highly effective (Fig. 6).

The inconsistent extermination of brambles obtained with ammonium sulfocyanate treatments is accounted for by two factors, *viz.*, (1) the relatively rapid rate at which the toxicity of the compound is dissipated after it comes in contact with the soil, and (2) rainfall and temperature factors. To be most effective the major absorption of this toxic agent must take place thru the bramble leaves and canes. Lack of rainfall permits the sulfocyanate to remain on the aerial parts for a maximum period. Dry weather, combined with heat, weakens brambles generally. It also creates a water deficit within the plants, thereby hastening the rate at which the toxic spray is absorbed from the leaf surfaces and increases the extent of its distribution within the bramble plant organs.

Both in crude liquor and crude crystalline forms, ammonium sulfocyanate sprays on foliage caused a rapid withering and burning of leaves and cane tips. Typical ammonium sulfocyanate action on bramble foliage in a June treatment is shown in Figs. 4 and 5. Effects in wilting and discoloration of leaves were noticeable 2 hours after application, and defoliation followed in a few days. Internal effects, such as drying and discoloration of cambium and wood tissues, were first visible in the canes from 5 to 24 hours after treatment. The rate and the extent to which these reactions progressed thru the bramble plant systems varied with seasons of treatment, being greater during summer than spring and during spring than autumn. Altho less obvious, these internal reactions proved to be more indicative of the ultimate success of an eradication project than was the initial action on foliage. In fact, too rapid killing of leaves by an herbicide is not desirable, as it naturally would interfere with the absorption of toxic chemicals.

The rather transient nature of the toxic action of ammonium sulfocyanate unquestionably makes it less generally effective than the chlorates and arsenite as a bramble eradicator and requires that it be

used within a more limited range of conditions. On the other hand, this property of the material is a decided advantage in that any soil injury following its use is also of short duration, lasting usually only a few weeks or months. Furthermore, in this connection, when soil toxicity has passed after the use of these materials the fertilizing nitrogenous

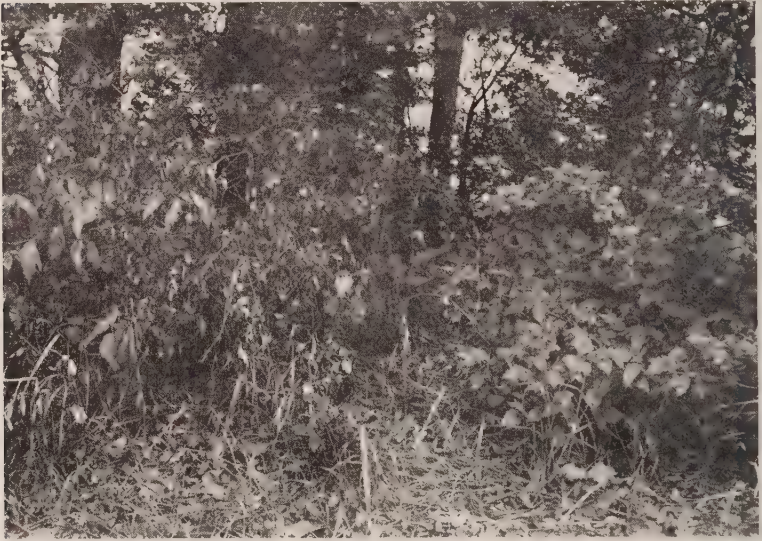


FIG. 4.—WILD BRAMBLES 24 HOURS AFTER SPRAYING WITH AMMONIUM SULFOCYANATE.

Note wilted condition of treated plants on left compared with untreated growth on right. Treated plat was a mixed stand of red raspberries and blackberries with a vigor-index of 7. Rate of application: 2 pounds of crystals in 1 gallon of water per 100 square feet. Method of application: Fine mist spray on foliage under low pressure. Date of application: June 11, 1934.

residues become available, rendering the soil more productive than it was previously. No cultivated crops were grown on sulfo cyanate-treated areas, but this fertilizing influence was markedly apparent in the rank growth and darker leaves of surviving brambles and of grasses and weeds that subsequently invaded the plats. Wherever bramble-covered areas are wanted for crop production after eradication, this advantage should be an important consideration.

No fire risk is incurred with the use of the sulfo cyanates. Because the sulfo cyanates have a repellent odor and destroy plant foliage rapid-

ly, livestock will not feed on treated herbage, thus eliminating any hazard from stock poisoning.

Directly comparable tests of the two ammonium sulfocyanate materials were not made and it is not possible to state definitely whether there is any difference between them in effectiveness as bramble eradi-



FIG. 5.—WILD BRAMBLES 2 MONTHS AFTER SPRAYING WITH AMMONIUM SULFOCYANATE.

Same plat as that shown in Fig. 4 viewed from a different angle. Note that the foliage on the red raspberries has all withered and dropped, while the more resistant blackberry clump still retains portions of its foliage on a few shoots.

cants. Against common weeds, the Koppers Products Company⁴ has found the liquor to be slightly more toxic than the crystals. This statement would probably hold true with brambles also. The soil injury phase is of shorter duration with the crystals, due to absence of the oil impurities that the liquor contains. In all batches of the crystalline material used an insoluble sludge was present that caused clogging of sprayers unless removed from the solution by straining thru cloth filters. This sludge was not present in the liquor.

⁴*Loc. cit.*

The cost of ammonium sulfocyanate at the time of these bramble extermination investigations was relatively high. If these materials become more widely used, the resultant increased production will probably bring about lower prices. The crude crystalline form was appreciably more expensive than the crude liquor per unit of toxic ma-



FIG. 6.—WILD BRAMBLE PLAT 15 MONTHS AFTER SPRAYING WITH AMMONIUM SULFOCYANATE.

Same plat as that shown in Figs. 4 and 5. A few small red raspberry shoots survived. The wild blackberry clump did not expire completely and at the time the picture was taken (Sept. 26, 1935) was making a vigorous recovery. The extra-green color of its foliage does not show.

terial. In quantity purchases delivered at Fredonia, N. Y., in 1933, the crystals cost 13 cents per pound while the liquor cost 22 cents per gallon, or 6 to 8 cents per pound of crystal content. Treatments recommended for average conditions cost, respectively, 39 cents and 22 cents per 100 square feet (Table 5).

Recommendations for use.—For small projects in bramble extermination, the use of the crude crystalline ammonium sulfocyanate is advised because of convenience in handling and storage. It should be made up as needed in water solutions of 3 pounds per gallon. For

larger projects covering a total of 2,500 square feet or more the crude liquor is to be preferred because of lower cost, and it should be used undiluted. Either solution should be applied as a fine mist spray on the bramble foliage during a drouth period in summer and in quantity sufficient to cover all growth uniformly dripping wet. Under average conditions such application would approximate 1 gallon per 100 square feet. Heavier rates of application should be used in spring or autumn treatments. Applications by other means than spraying, or to the soil surfaces, or in the dormant season are not advised with these products.

Risks.—These crude ammonium sulfocyanate compounds are mildly caustic to the skin of humans and animals, cause shrinking and cracking of leather, and will corrode metals rapidly. For these reasons, the following precautions in using them are suggested: Avoid getting solutions on skin and on clothing, especially leather gloves, boots, or shoes. Should mild accidents of either type occur, wash skin or clothing immediately with cold water. Spilling and spray drift of this material on sprayers should be avoided. It is well to see that all external metal parts of sprayers have a protective covering of paint. All leather gaskets in pumps and nozzles should be freshly greased. Immediately after applying ammonium sulfocyanate, spray equipment should be rinsed with more than usual thoroughness and again before fungicides or insecticides are applied with it.

CHLORATES

Sodium chlorate is a white salt chemically closely related to and resembling in both appearance and taste the common salt of commerce. The former, however, has an unusually strong oxidizing power—a characteristic entirely lacking in common salt. This oxidizing power accounts for the weed-killing value of sodium chlorate, but it also introduces an undesirable fire risk.

Atlacide is the trade name of a chlorate weed killer. Originally (1928), this material was calcium chlorate,⁵ but more recently (1933) it has been composed of a mixture of approximately 60 per cent sodium chlorate and 40 per cent calcium chloride.⁶ In either case, the fire hazard of the material is reduced over that of pure sodium chlorate.

Vegecide is another proprietary chlorate product. Altho its exact chemical composition is not known, this material is basically similar to Atlacide, i. e., it is a chlorate with reduced fire hazard.

⁵Latshaw, W. L., and Zahnley, J. W. Magnesium and calcium chlorates as substitutes for sodium chlorate for killing field bindweed. *Jour. Amer. Soc. Agron.*, 20:1329. 1928.

⁶Cook, W. H. Fire hazards in the use of oxidizing agents as herbicides. *Can. Jour. Res.* 8: 509-544. 1933.

All the chlorate materials were in crystalline form and were readily soluble in water.

Apparently the chlorates are not extensively broken down by chemical reaction after they come in contact with soils.

Chlorates are injurious to alimentary tracts of men and animals if swallowed in considerable quantity, but may be classed as relatively nonpoisonous materials.

Experiments.—In the first trial of sodium chlorate, September 26, 1932, a water solution of 4 pounds of crystals in 2 gallons was sprayed as a fine mist on the bramble foliage of a 100-square-foot plat having a vigor-index of 6. Complete extermination had been achieved by June, 1933. In extensive demonstrations in the spring of 1933, applications of approximately 2 and 3 pounds per 100 square feet, made in the same general manner, both accomplished complete killing of all the wild red raspberries, some of which were extra-vigorous in growth (Table 1).

This material again applied by the same method in the experiment on rates of application (October 27, 1932), completely eradicated all growth of red raspberries on the 4-pound and 2-pound plats and achieved 90 per cent kill on the 1-pound plat where the bramble growth had a vigor-index rating of 8 (Table 2). In experiments on various methods of applying herbicides (October, 1933), a treatment of 2 pounds per gallon per plat gave 100, 100, 100, 98, and 97 per cent exterminations when applied to foliage, respectively, as a fine mist spray under low pressure, as a fine mist spray under high pressure, as a coarse spray under high pressure, by sprinkling, and by dusting. The second of these plats had an unusually high vigor-index (9). Applications of sodium chlorate to the soil surface by three methods gave eradications estimated at 95, 94, and 92 per cent (Table 3). In a time-of-application experiment during 1934, complete killing of all brambles followed sprays of 2 pounds per gallon per plat in all five growing-season treatments. Application to the soil at the same rate on December 6 was found to have been 97 per cent effective in June 1935 (Table 4).

Atlacide and Vegecide each received three separate trials in the general experiments. In respective spray applications of 4 and 3 pounds and of 4 and 2½ pounds per 100 square feet against bramble growth of average vigor, both were fully eradicated. Neither was entirely effective on maximum growth under favorable environment (vigor-index of 10), Atlacide producing 80 per cent and Vegecide 75 per cent exterminations following respective applications of approximately 4 and 3 pounds per 100 square feet (Table 1).

In the rate-of-application treatments of October 27, 1932, both proprietary chlorates completely eradicated all red raspberry growth on 100-square-foot plats in spray applications of both 4 and 2 pounds. At the 1-pound rate, Vegecide completely killed all growth on a plat having a low vigor-index (3) and Atlacide gave 75 per cent eradication on a plat where the vigor-index was 7 (Table 2). In the experiments com-

paring methods of application, Atlacide and Vegecide accomplished results similar to one another. Respectively, these materials gave 100, 100, 92, 90, and 85 and 95, 100, 88, 90, and 88 per cent kills when applied by the five methods to the foliage, and 85 and 82 per cent exterminations respectively when sprinkled on the soil surface after the raspberry canes had been mowed (Table 3).

Discussion.—Sodium chlorate was noteworthy, thruout the experiments reported above, for the consistently high degree of bramble



FIG. 7.—WILD BRAMBLE PLAT 15 MONTHS AFTER SPRAYING WITH SODIUM CHLORATE.

Originally, this plat had a dense stand of red raspberries with a vigor-index of 8. The rate of application was 2 pounds in 1 gallon of water per 100 square feet. The material was applied as a fine mist spray on foliage under low pressure. Date of application June 11, 1934. Complete eradication of brambles was achieved.

eradication that followed its use. (See Figs. 7 and 8.) With all the varying rates, methods, and times of application and of bramble plat conditions, never less than 90 per cent success was obtained with this chemical. It was most eradivative when applied as a fine mist spray on the foliage. Satisfactory eradication was achieved, however, with applications made by sprinkling, by hand distribution of dry crystals, by

application to the soil instead of the foliage, and at all seasons, even winter.

The two proprietary chlorates were also consistently effective. Against vigorous growth, or when applied at the lower rates, or by the less effective methods, they were inferior to pure sodium chlorate.



FIG. 8.—WILD BRAMBLES EXTERMINATED BY SODIUM CHLORATE TREATMENT.

Photo May 25, 1934. One year previously at time of treatment, June 13, 1933, this was a most vigorous mixed stand of blackberries and red raspberries among sumac brush. The rate of application was high, approximately 3 pounds in $1\frac{1}{2}$ gallons of water per 100 square feet. A fine mist spray on foliage under high pressure was used.

Chlorate-sprayed bramble foliage lost its moisture and green color slowly and did not drop from the canes for several weeks. The slow rate at which initial external effect from chlorate applications was shown was in marked contrast to the rapidity of action characteristic of ammonium sulfocyanate, but the internal action of the chlorates on wood and cambium tissues, especially in the underground plant organs, was always more drastic and extensive.

Probably two reasons explain the greater consistency in bramble destruction obtained with the chlorates in comparison with the sulfocy-

anates. First, the former do not kill the foliage so rapidly, thus permitting more extensive absorption thru the leaf surfaces. Second, and more important, the chlorates retain their toxicity after contact with the soil, remaining therein unchanged for several months until leached down into the substrata by rains. During this period they are continuously absorbed by the bramble roots and stolons, supplementing the killing process initiated by leaf absorption. In fact, to judge from the experiments reported above, the underground absorption phase may be of greater consequence than leaf absorption.

Bramble plats that have been foliage treated with chlorates should never be burned over intentionally. Such a practice might seem to facilitate eradication, but actually it simply wastes the unabsorbed chlorate oxidizing material in non-effectual flame.

The costs of chlorate treatments were moderate. When purchased in 100-pound quantities, delivered at Fredonia, N. Y., at the time of these experiments, sodium chlorate cost approximately 8 cents per pound and Atlacide and Vegecide each 11 cents per pound. It is recommended that the proprietary chlorates be used at higher rates of application than the unmixed sodium chlorate. For the suggested average treatments, the cost of eradication for materials only per 100 square feet of land area was 12 cents with sodium chlorate and 22 cents with Atlacide or Vegecide (Table 5).

Recommendations for use.—When applied by the most effective method, *viz.*, as a fine mist spray on foliage, sodium chlorate should be made up in water solutions of 1 to 2 pounds per gallon. The bramble leaves and canes should be sprayed with this solution until they are drenched. This will require about 1 gallon per 100 square feet under average conditions. Employing the same method, the concentration of the proprietary chlorates should be 2 pounds per gallon. Foliage sprays of chlorates may be applied at any time during the growing season.

Treatments with chlorates may also be made by sprinkling or even by dry distribution of the crystals. Applications to soil surfaces and in the dormant season will be effective, too. With these less efficient methods, however, the rate of application might better be increased one-half. Use of mechanical dusters for applying chlorates is inadvisable.

Risks.—Sodium chlorate is slightly caustic to skin and quite corrosive to metals. Precautionary advice in this regard given on page 15 in a discussion of the use of ammonium sulfoeyanate materials is also applicable to the use of sodium chlorate.

Chlorate-treated foliage has a decided salty taste that is relished by salt-hungry animals. If consumed in quantity, it would be injurious; but experience in western states indicates that if the craving for minerals has been and is kept appeased, livestock may safely be grazed in access to chlorate-treated weeds.

The harmful effects of chlorates on treated soils at the rates of application recommended will be apparent for a period of 6 to 18 months, depending on soil type and rainfall.

The most serious drawback to the use of chlorates is the risk of fire; but by understanding the nature of the material and exercising simple precautionary measures, this risk may be nullified entirely. Curiously enough, pure sodium chlorate will not catch fire under heat, shock, or friction of any sort or intensity. All chlorates are perfectly safe chemicals alone, *but become dangerous when mixed with sulfur or with any readily combustible, dry, organic matter* like dust, clothing, paper, charcoal, or wood. Once combustion is initiated in such mixtures, the process is speeded up by the contribution of the oxygen in the chlorate. Just how much energy is required to start the process and how intense it will become is determined by the quantity of the mixture, by the ratio of chlorate to combustible constituents, by the original inflammability of other constituents, and by external conditions of atmospheric temperature and humidity. Given the proper conditions, fire may be set off in such mixtures by friction, shock, or heat. Danger of spontaneous combustion, however, is not likely under the weather conditions usually obtaining in the northeastern United States. In any case, there can be no possibility of accidental fires with the use of chlorates in this region if two general principles are strictly adhered to, namely, (1) do not allow the unintentional mixing of chlorate with other material to occur, and (2) keep fires away from foliage-treated plats; or apply the chlorate to the soil in autumn or winter.

More explicit instructions are always to store and transfer chlorate materials in the original tight-lidded steel drums in which they come from the factories and to keep the covers on tight. These drums should be stored in a shed remote from dwelling houses and barns, and where children or irresponsible parties cannot obtain access to them. Never store chlorates in the same building with sulfur in any form. All measuring and other handling of chlorates should be done *on the ground in the field*. Avoid spilling in or about buildings, in wagon or truck boxes, etc., where it may remain as a fire hazard to flare up later. Do not use chlorate sprays near frame buildings. Keep all wooden parts of spray-

ers or vehicles used around chlorate sprays well painted to prevent absorption. Sprayers that have had sulfur-containing fungicides in them should have the sulfur removed thoroly, internally and externally, before chlorate solutions are put in.

Clothing that is once wetted with chlorate solution becomes a fire hazard *when dry*. Some of the most serious accidents with the use of chlorates have resulted from thoughtlessness in this regard.

Chlorates should not be used on brambles growing under or near valuable trees or shrubs. Large trees may not show appreciable injury from moderate applications of chlorate under them, but most shrubs are quite sensitive to chlorate applications around them.

SODIUM ARSENITE

Sodium arsenite has been used as a weed killer since early in the present century. It is an unstable compound and cannot be purchased in a prepared crystalline or powder form. Several proprietary weed killers for sale in liquid form contain sodium arsenite as their base. These, however, are of rather variable composition and besides are quite expensive.

A home-made sodium arsenite solution was used in these experiments on bramble eradication. The formula was as follows: One-half pound white arsenic (arsenic trioxide, 80 per cent grade), 2 pounds washing soda (sodium carbonate), and $\frac{1}{2}$ gallon water. This mixture was boiled 20 minutes, then made up to 2 gallons by adding water.

All compounds of arsenic, but especially the soluble arsenite forms, are extremely poisonous to men and animals when taken internally, even in minute quantities.

The presence of arsenic in soils in any appreciable proportion prevents plant growth. Arsenic is fixed chemically by soils so that it is retained against leaching.

Experiments.—The full formula given above was applied in the autumn of 1933 as a fine mist spray on the foliage of wild red raspberries covering a 100-square-foot plat. No plant growth of any sort was found on this plat in the spring of 1934. June 11, 1934, one-half the formula was applied by the same method to wild raspberries on another plat of similar size, and by autumn all bramble growth had been killed. Both plats were of average growth and environment, having vigor-indices of 6 and 5, respectively (Table 1).

Discussion.—Experimentation with sodium arsenite was intentionally limited. All the bramble eradication plats were located on property belonging to cooperating farmers, where soil ruination and unnecessary risks with stock-poisoning were to be avoided. The two trials of this material were so conclusive, however, as to leave no doubt of its efficacy in destroying wild red raspberries. General use of sodium

arsenite in bramble eradication is not recommended, but it may be employed in limited cases where its disadvantages are appreciated and are not considered objectionable.

From the standpoint of cost of material only on a bulk-purchase basis, sodium arsenite was the cheapest of the effective treatments tried in these tests. The treatment recommended for average conditions requires $\frac{1}{4}$ pound of white arsenic and 1 pound of washing soda per 100 square feet, at an approximate cost of 6 cents (Table 5).

Recommendations for use.—Sodium arsenite solution may be made up in any quantity desired, but the proportions given in the formula above should be maintained. For average conditions, 1 gallon of this material per 100 square feet should suffice, irrespective of method or season of application.

Risks.—Extreme caution must be exercised in all phases of the storage, handling, preparation, and application of arsenicals. During the home manufacture of the weed-killing arsenite solution, care must be taken against inhaling the vapor rising from the boiling mixture and hands should be kept away from the face. Utensils used in this process should be washed thoroly and should never subsequently be used for cooking food.

Sodium arsenite should never be applied on foliage where there is the least chance that livestock can get it. Winter application to the soil surface might be slightly less effective but would eliminate the possibilities of stock poisoning.

When washed into a soil at the rate of application necessary to kill brambles, sodium arsenite will make the soil sterile for growth of crops for an extended period. The deleterious effects have been known to persist after seven years. Soil injury, however, is not always an important factor as sometimes the brambles to be exterminated are situated on land that will never be wanted for agricultural production.

ADDITIONAL CONSIDERATIONS

Species resistance to herbicides.—In the extensive field demonstrations of May and June, 1933, naturally mixed stands containing all sorts of indigenous wild brambles were treated, and in many of the experimental plats, blackberries and black raspberries were present among the red raspberries. Thus, opportunity was afforded for studying species differences in resistance to herbicides. Without exception, all of the black raspberries and dewberries were killed. The red raspberries succumbed with uniform readiness in all cases except those

where vigor was exceptional. None of the few clumps of purple raspberries that were encountered were completely exterminated. Wild blackberries appeared to be the most resistant type (Fig. 6). Indications were that clumps of this species will ordinarily require somewhat heavier applications or follow-up treatments.

Influence of soils.—Most of the bramble eradication treatments were made on soils of sandy loam or gravelly loam types, characteristic of the berry-growing areas of western New York. For the most part, these soils tend to lack humus and fertility and to dry out rapidly. A few experiences on heavier and more fertile soils, with steadier water supply, indicated that the brambles resisted the herbicides more under such conditions. This effect, however, was probably due less to direct differences in soils than to the indirect differences in vigor of bramble growth. Chlorates leach more rapidly from light than from heavy soils.

Influence of bramble vigor.—A resumé of the data reported in Tables 1 to 4, inclusive, with particular attention to rates of application and to plot vigor-indices, shows that resistance to herbicides increased conspicuously as the vigor of bramble growth increased. This greater resistance, however, was never insurmountable, being overcome by heavier initial applications of chemical or follow-up treatments.

Weather conditions.—From late June, 1932, until October, 1934, the period during which these investigations on chemical eradication were conducted, western New York experienced a weather cycle of abnormally low precipitation and, except in the winter of 1933–34, of higher than normal temperatures. The climax of this cycle came in an unprecedented drouth period lasting thruout the growing season of 1934.

Whether such conditions aided or hindered the bramble eradication may only be surmised. There seems little doubt that eradication with ammonium sulfocyanate was enhanced by hot, dry weather. Chlorate toxicity is reputedly lowered in dry soils, but this effect may be more than offset by the fact that a deficit of soil moisture affects bramble growth adversely and presumably would lower its resistance to a toxic factor. Also, heavier rainfall will leach the chlorates away more rapidly. All in all, it is doubtful whether the uniformly excellent measure of eradication obtained in all experiments of the 1934 growing season, especially with ammonium sulfocyanate, could be duplicated in seasons of normal rainfall. On the other hand, there is no reason to believe that abnormal weather is essential to effective bramble extermina-

tion with sulfocyanates and chlorates. Sodium arsenite, because of the nature of its toxicity and its endurance in the soil, at the rate recommended might well be expected to be eradivative under all weather conditions.

Time of application.—As a general rule, the reserve strength of plants is most depleted at the time of fruit maturity. Theoretically, then, they would be most susceptible to the application of toxic chemicals at such times. Also, from the standpoint of season, plants generally suffer seriously from any adverse condition during the heat and drouth of midsummer. With brambles, fruit maturity and midsummer are coincident. Consequently, theory would indicate July or August as the optimum time to apply herbicides to brambles for greatest effectiveness. That this is true in practice is substantiated by the data presented in Table 4, but just how necessary it is that applications be made at this optimum season apparently varies with the nature of the material. Certainly, the action of ammonium sulfocyanate is influenced much more by season than is the case with the chlorates and arsenite.

Other factors than time of maximum effectiveness enter into a consideration of when to apply herbicides to brambles. The fire hazard with chlorates is highest in the hot, dry weather of summer. Where this is feared, spring or autumn applications would be better. Possibility of stock poisoning with sodium arsenite would make a dormant application with this material preferable. Still another consideration is that such work as eradication of brambles is classed as an odd-job enterprise to be done in lull periods between the rush seasons of the major farm projects. Providing almost as effective results can be obtained at one time as another, farmers would naturally prefer to choose a time for chemical treatment of brambles when other work is less pressing.

Method of application.—All materials were of maximum effect against wild red raspberries when they were sprayed in a fine mist on the foliage. Pressures of 150 to 200 pounds were a trifle more effective than pressures of 25 to 50 pounds. Sprinkling and coarse spray were effective methods with sodium chlorate, but less so with the other materials. Dusting crystalline ammonium sulfocyanate and the chlorates on foliage gave fairly satisfactory eradication (Table 3). This is not, however, a practical method since these materials gather moisture from the air so rapidly as to interfere with their distribution in dry form.

The differences in eradication obtained by the five methods of application to foliage seemed to be accounted for entirely by the variations

in the mechanical efficiency with which the materials were distributed. A fine mist spray under high pressure divides a material into the smallest particles and spreads them most evenly over plant foliage or soil area. For treatment of small patches or where no spray equipment is available, however, the sprinkler method should give worth while results, especially if a greater volume of water is used to apply the same weight of material.

Mowing of brambles prior to application of herbicides in autumn tests did no good in some cases and actually lessened eradication in others.

Number of treatments.—From the beginning, the goal sought in these investigations was complete eradication with one application of a given chemical. The above recommendations on method, time, and rate of applications made for each of the effective materials are on that basis. In several of the experiments where eradication was incomplete following a single application, second treatments were made and these invariably finished the job. These second or follow-up applications came 5 months to 1 year later, allowing ample time in each instance for the full effect of the first treatment to show. Such repeat applications required but little material as they were not made at the original rates but average dilutions were sprayed on the surviving bramble foliage until it was drenched. These experiences indicated that economy of materials could probably be effected, tho with increased labor cost, by a two-treatment schedule in which an initial application is made at one-half the recommended rate followed by a light second application several months later.

Rate of application.—A general average rate of application may be recommended for any one of the effective materials, as indicated on pages 14, 19, and 22 and in Table 5; but consideration of the factors outlined above shows that rates should be varied according to species of bramble, vigor of growth, soil type and fertility, method of application, season of application, and whether eradication is to be accomplished in one treatment.

Rates of application may be varied at two points, *viz.*, the concentration of solutions can be raised or lowered, and the amount of spray per unit area can be increased or decreased. High concentrations reduce the handling and transporting of water, on the one hand, but on the other hand, if they are too high, it is difficult to obtain the essential uniform dispersal of the limited quantity of materials over a given area.

Cost of materials.—The cost of a chemical eradication project on wild brambles will vary widely with the chemical selected, quantity and source of its purchase, prevailing prices, and rate of application. (See Table 5.) Taking the sodium chlorate treatment recommended for average conditions as a standard, i.e., $1\frac{1}{2}$ pounds per 100 square feet, the cost for material at prices obtaining in 1933, was 12 cents, or approximately \$52.00 per acre. At first glance, this acreage cost appears prohibitive. But, unlike the perennial herbaceous weeds, brambles in the wild state grow in patches, rarely on an acreage scale. Also, the major object in eradicating brambles is usually not to return the land to production, but either to dispose of unsightly nuisances or to eliminate an important harbor of disease and insect pests for cultivated brambles—sometimes both. More expense is justified where these aims are in view.

SUMMARY

Experience with common methods of destroying wild brambles, such as clean cultivation, grubbing, mowing, burning, and livestock grazing, has demonstrated their efficiency when properly managed; but in many situations, none of these means is expedient.

In experimentation with chemicals, the effective bramble eradicates proved to be ammonium sulfocyanate, both crude-liquor and crude-crystalline; sodium chlorate and the proprietary chlorate mixtures, Atlacide and Vegecide; and sodium arsenite. Recommendations on the use of these materials have been evolved from the results of plat experiments and field trials with different rates, methods, and seasons of application and from a general consideration of their chemical natures and plant toxicity.

In comparison with the above materials, sodium chloride, kerosene, sulfuric acid, lime-sulfur, copper sulfate, ammonium sulfate, calcium cyanamide, sodium nitrate, and sodium carbonate were found to have slight or no value in the destruction of brambles.

Of the several types of wild brambles, blackberries proved most resistant to all of the toxic chemicals. Purple or hybrid raspberries (a relatively rare species) were also quite resistant. Wild red raspberries (the most numerous species and the main objective of this work), black raspberries, and dewberries, all succumbed readily to the action of effective materials.

Resistance to herbicides rose with increased vigor of bramble growth. A fine mist spray applied on the foliage proved to be the most effec-

tive method of treating brambles with herbicides. Methods less efficient in distributing the materials, such as dusting or sprinkling the foliage, and applications to soil surfaces instead of foliage, gave good results with the chlorates but not with ammonium sulfocyanate.

Brambles appeared to be most susceptible to applications of toxic materials when the treatments were made at about time of fruiting in midsummer. At other times sodium chlorate was less effective, but still it was satisfactorily eradicated at every season of application, even winter. Ammonium sulfocyanate was appreciably less eradicated in spring and fall and non-effectual in winter treatments.

TABLE 1. TRIALS OF CHEMICALS TO KILL WILD BRAMBLES, CHIEFLY RED RASPBERRIES.

| MATERIALS | RATE OF APPLICATION PER 100 SQ. FT. | METHOD OF APPLICATION* | VIGOR-INDEX OF PLANT† | ESTIMATED GROWTH OF BRAMBLES AFTER TREATMENT (ORIGINAL CONDITION = 100) | | | | | |
|--|-------------------------------------|------------------------|-----------------------|---|------------|-----------|------------|-----------|------------|
| | | | | June 1933 | Sept. 1933 | June 1934 | Sept. 1934 | June 1935 | Sept. 1935 |
| Ammonium sulfate‡. | 5 lbs. in 2 gal. water | A | 7 | — | — | — | 80 | 110 | 150 |
| Ammonium sulfocyanate§ (crude liquor) | 2 gal., undiluted | B | 3 to 9 | — | 0 | 1 | 1 | 5 | — |
| Ammonium sulfocyanate (crude liquor) | 1½ gal., undiluted | B | 7 | — | 2 | 10 | 20 | 25 | — |
| Ammonium sulfocyanate+ (crude crystalline) | 4 lbs. in 2 gal. water | A | 6 | 5 | 12 | 25 | — | — | — |
| Atlacidé+. | 4 lbs. in 2 gal. water | A | 5 | 0 | 0 | 0 | — | — | — |
| Atlacidé | 4 lbs. in 2 gal. water | B | 10 | — | 20 | 20 | 25 | 30 | — |
| Atlacidé*. | 3 lbs. in 1½ gal. water | B | 5 | — | 0 | 0 | 0 | — | — |
| Calcium cyanamidé‡. | 2 lbs. | E | 8 | — | — | — | 100 | 105 | 120 |
| Calcium cyanamidé†. | 5 lbs. | E | 8 | — | — | — | 90 | 95 | 130 |
| Calcium cyanamidé‡. | 10 lbs. | E | 6 | — | — | — | 65 | 90 | 95 |
| Copper sulfate††. | 4 lbs. in 2 gal. water | A | 6 | — | — | 90 | 100 | 100 | — |
| Kerosene††. | 2 gal. | A | 7 | — | — | 50 | 90 | 100 | — |
| Lime-sulfur††. | 2 gal. 33° Baumé | A | 6 | — | — | 80 | 100 | 100 | — |
| Sodium arsenite solution†† | 2 gal. ++ | A | 6 | — | — | 0 | 0 | 0 | — |
| Sodium arsenite solution‡ | 1 gal. ++ | A | 5 | — | — | — | 0 | 0 | 0 |
| Sodium carbonate††. | 5 lbs. in 2 gal. water | A | 6 | — | — | 100 | 100 | 100 | — |

| | | | | | | | |
|-------------------------------------|--------------------------|---|--------|---|----|----|-----|
| Sodium chlorate ⁺ | 4 lbs. in 2 gal. water | A | 6 | 0 | 0 | — | — |
| Sodium chlorate ^{††} | 2 lbs. in 1 gal. water | B | 6 to 8 | 0 | 1 | 2 | — |
| Sodium chlorate ^{§§} | 3 lbs. in 1½ gal. water | B | 4 to 7 | — | 0 | 0 | — |
| Sodium chloride ^{††} | 10 lbs. | H | 6 | — | 75 | 85 | 80 |
| Sodium chloride ^{††} | 100 lbs. | H | 7 | — | — | 5 | 10 |
| Sodium nitrate [†] | 5 lbs. in 2 gal. water | A | 7 | — | — | 90 | 110 |
| Sulfuric acid ^{††} | 2 lbs., 25% con. | A | 6 | — | — | 50 | 90 |
| Vegetide ⁺ | 4 lbs. in 2 gal. water | A | 4 | 0 | 0 | — | — |
| Vegetide | 2½ lbs. in 1¼ gal. water | B | 6 | — | 0 | 0 | — |
| Vegetide | 3 lbs. in 1½ gal. water | B | 10 | — | 25 | 40 | 65 |

*Methods of application were: A = In fine mist spray on foliage under 25 to 50 pounds pressure.

B = In fine mist spray on foliage under 150 to 200 pounds pressure.

E = Distributed dry thru hand-agitated sieve on foliage.

H = Broadcast dry by hand on soil surface.

††It was impossible to find numerous plats of wild brambles closely comparable in stand, vigor, soil type and fertility, and ecological associations; yet these factors influenced results and should be kept in mind when comparing effects of various treatments (last column). For economy of space, in this and future tables individual plat conditions are not described, but their sums are represented by estimated index numbers on an imaginary scale of 1 to 10; from stunted growth under conditions most unfavorable to brambles (1), thru average (5 and 6), to luxuriant growth in an optimum bramble environment (10). For illustrations see Figs. 1, 2, and 3.

††Treated plat measured 100 sq. ft. and was located on gravelly-loam soil on the Cattaraugus Indian Reservation near Brant. Date of application June 11, 1934.

§§Treated areas totaled an estimated 1,900 sq. ft. Located on gravelly-loam soil on the Cattaraugus Indian Reservation near Gowanda. Date of application May 29, 1933.

†Treated clumps totaled an estimated 800 sq. ft. Located on clay loam soil near Collins Center. Date of application May 30, 1933.

†Treated plat measured 100 sq. ft. and was located on sandy loam soil near Brant. Date of application Sept. 26, 1932.

**Treated plat was 150 sq. ft. in size. Located on clay loam soil near Collins Center. Date of application May 31, 1933.

††Treated plat measured 100 sq. ft. and was located on gravelly loam soil on the Cattaraugus Indian Reservation near Brant. Date of application Sept. 28, 1933.

††The several treated areas covered an estimated 4,200 sq. ft. Located on gravelly loam soil on the Cattaraugus Indian Reservation near Brant. Date of application May 31, 1933.

§§The several treated areas covered an estimated 1,500 sq. ft. Located on gravelly loam soil on the Cattaraugus Indian Reservation near Brant. Date of application June 13, 1933.

††Three separate bramble clumps treated, totalling an estimated 500 sq. ft. Located on clay loam soil near Collins Center. Date of application May 30, 1933.

+ Sodium arsenite solution was home-made according to following formula:

Arsenic trioxide (As₂O₃, commonly called "white", arsenic), 80% grade, ½ pound

Sodium carbonate (Na₂CO₃·10H₂O, commonly known as "salsoda" or "washing soda"), 2 pounds

Water, ½ gallon

Boiled 20 minutes and made up to 2 gallons by adding water

TABLE 2.—TEST OF FOUR HERBICIDES ON WILD RED RASPBERRIES TO DETERMINE OPTIMUM RATE OF APPLICATION, 1933.*

| MATERIALS | SECTION 1: RATE 4 POUNDS | | | SECTION 2: RATE 2 POUNDS | | | SECTION 3: RATE 1 POUND | | |
|--|--------------------------|---|-------|--------------------------|---|-------|-------------------------|---|-------|
| | Vigor-index of plat | Estimated growth after treatment (original condition = 100) | | Vigor-index of plat | Estimated growth after treatment (original condition = 100) | | Vigor-index of plat | Estimated growth after treatment (original condition = 100) | |
| | | June | Sept. | | June | Sept. | | June | Sept. |
| Ammonium sulfocyanate (crude crystals) | 6 | 5 | 10 | 6† | 40 | 60 | 7 | 75 | 110 |
| Sodium chlorate..... | 7 | 0 | 0 | 5 | 0 | 0 | 8 | 10 | 10 |
| Atlaclde..... | 6 | 0 | 0 | 4 | 0 | 0 | 7 | 25 | 50 |
| Vegecide..... | 5 | 0 | 0 | 4 | 0 | 0 | 3 | 0 | 0 |

*All plats were 100 sq. ft. in area. Applications were made Oct. 27, 1932. Materials, in amounts given, were dissolved in 2 gallons of water and sprayed on foliage in fine mist under 25 to 50 pounds pressure. Plats of sections 1 and 2 were on sandy loam soil near Brant; those of section 3 were on clay loam soil near North Collins.

†This plat was a mixed stand of wild red raspberries and blackberries. The greater resistance of the latter species to herbicidal action accounted for a considerable part of the poor showing made by the ammonium sulfocyanate in comparison with the chlorates in this section.

TABLE 3.—A COMPARISON OF THE EFFECTIVENESS OF VARIOUS METHODS OF APPLYING HERBICIDES TO ERADICATE WILD RED RASPBERRIES, 1934.*

| METHOD OF APPLICATION† | AMMONIUM SULFOCYANATE (CRUDE CRYSTALLINE) | | | SODIUM CHLORATE | | | ATLACIDE | | | VEGECLIDE | | |
|------------------------------|--|--|-------|-------------------------------|--|-------------------------------|--|-------|-------------------------------|--|-------|--|
| | Vigor- index of plat | Estimated growth after treatment (original condi- tion = 100) | | Vigor- index of plat | Estimated growth after treatment (original condi- tion = 100) | Vigor- index of plat | Estimated growth after treatment (original condi- tion = 100) | | Vigor- index of plat | Estimated growth after treatment (original condi- tion = 100) | | |
| | | June | Sept. | | | | June | Sept. | | June | Sept. | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| On Foliage | | | | | | | | | | | | |
| A..... | 6 | 30 | 35 | 5 | 0 | 1 | 4 | 0 | 7 | 5 | 8 | |
| B..... | 6 | 18 | 25 | 9 | 0 | 0 | 7 | 0 | 6 | 0 | 0 | |
| C..... | 4 | 22 | 25 | 5 | 0 | 0 | 6 | 8 | 7 | 12 | 15 | |
| D..... | 7 | 37 | 40 | 5 | 2 | 3 | 6 | 10 | 6 | 10 | 10 | |
| E†..... | 5 | 50 | 65 | 6 | 3 | 3 | 5 | 15 | 5 | 12 | 10 | |
| On Soil Surface | | | | | | | | | | | | |
| F..... | 8 | 150 | 200 | 9 | 5 | 6 | 8 | 15 | 8 | 18 | 25 | |
| G..... | 7 | 125 | 150 | 7 | 6 | 10 | — | — | — | — | — | |
| H†..... | 6 | 110 | 200 | 8 | 8 | 10 | — | — | — | — | — | |

*All plots were 100 sq. ft. in area. Applications were made in Oct., 1933. A standard rate of application, 2 pounds of each material, were used on all plots. These plots were all located in one area on the Cattaraugus Indian Reservation on gravelly loam soil.

†Methods of application were:

A = Material dissolved in 1 gal. of water; applied as fine mist spray under 25 to 50 lbs. pressure.

B = Material dissolved in 1 gal. of water; applied as fine mist spray under 150 to 200 lbs. pressure.

C = Material dissolved in 1 gal. of water; applied in coarse, fan spray under 150 to 200 lbs. pressure.

D = Material dissolved in 1 gal. of water; applied with sprinkling can.

E = Material distributed dry thru hand-agitated sieve.

F = Material dissolved in 1 gal. of water; applied with sprinkling can after mowing.

G = Material dissolved in 1 gal. of water; applied with sprinkling can; plots not mowed.

H = Material distributed dry by hand; plots not mowed. Soil moist after rain.

†Because of extreme deliquescence, ammonium sulfo cyanate was very difficult to distribute uniformly in crystalline form. The proprietary chlorates were also troublesome in this regard.

TABLE 4.—COMPARISONS OF THE EFFECTIVENESS OF DIFFERENT TIMES OF APPLYING AMMONIUM SULFOCYANATE (CRUDE CRYSTALLINE) AND SODIUM CHLORATE TO ERADICATE WILD RED RASPBERRIES.*

| DATE OF APPLICATION, 1934 | STATE OF BRAMBLE DEVELOPMENT | AMMONIUM SULFOCYANATE | | SODIUM CHLORATE | | | |
|---------------------------|---------------------------------|-----------------------|---|---------------------|---|------------|-------------|
| | | Vigor-index of plat | Estimated growth after treatment (original condition = 100) | Vigor-index of plat | Estimated growth after treatment (original condition = 100) | | |
| | | | June, 1935 | | Sept., 1935 | June, 1935 | Sept., 1935 |
| May 24..... | Fruit canes completely foliated | 7 | 2 | 8 | 7 | 0 | 0 |
| June 11..... | Full bloom | 7 | 2 | 5 | 8 | 0 | 0 |
| July 18..... | Mid-fruit-ripening | 7 | 0 | 0 | 8 | 0 | 0 |
| Aug. 17..... | Fruit canes senile | 6 | 0 | 0 | 6 | 0 | 0 |
| Sept. 20..... | Month before dormancy | 6 | 5 | 10 | 5 | 0 | 1 |
| Dec. 6..... | Dormant | 6 | 80 | 150 | 6 | 3 | 5 |

*Plats 100 sq. ft. in area. Rate 2 pounds of crystals in 1 gal. water. Applied as fine mist spray under low pressure. These plats were located on gravelly-loam soil on the Cattaraugus Indian Reservation. The five treatments during the growing season were made on the foliage; the sixth (December) treatment was made on soil surface.

TABLE 5.—COST OF MATERIALS IN CHEMICAL ERADICATION OF WILD BRAMBLES.*

| MATERIALS | COST PER POUND OR GALLON | RANGE IN RATES OF APPLICATION PER 100 SQ. FT. | AVERAGE RATE OF APPLICATION PER 100 SQ. FT. | RANGE IN COST PER 100 SQ. FT. | AVERAGE COST | |
|---|--------------------------|---|---|-------------------------------|--------------|---------|
| | | | | | 100 sq. ft. | 1 acre |
| Ammonium sulfocyanate (crude liquor, 30-35%)..... | \$0.22 | 1/2 to 2 gals. | 1 gal. | \$0.11-0.44 | \$0.22 | \$96.00 |
| Ammonium sulfocyanate (crude crystalline)..... | 0.13 | 2 to 6 lbs. | 3 lbs. | 0.26-0.78 | 0.39 | 170.00 |
| Atlatide..... | 0.11 | 1 to 4 lbs. | 2 lbs. | 0.11-0.44 | 0.22 | 96.00 |
| Sodium arsenite solution: | | | | | | |
| arsenic trioxide, 80% grade..... | 0.13 | 1/4 to 1/2 lb. | 1/4 lb. } | 0.06-0.11 | 0.06 | 26.00 |
| sodium carbonate..... | 0.02 | 1 to 2 lbs. | 1 lb. } | 0.08-0.24 | 0.12 | 52.00 |
| Sodium chlorate..... | 0.08 | 1 to 3 lbs. | 1 1/2 lbs. | 0.11-0.44 | 0.22 | 96.00 |
| Vegecide..... | 0.11 | 1 to 4 lbs. | 2 lbs. | | | |

*Materials are listed alphabetically. All prices are approximate and were those obtaining in purchases of 100-pound or 100-gallon lots direct from manufacturers, delivered at Fredonia, N. Y., in 1932 and 1933.